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ELECTROPHYSIOLOGIC STUDIES

Atrial Fibrillation in Patients With an Accessory Pathway: Importance Of the Conduction Properties of the Accessory Pathway

PAOLO DELLA BELLA, MD, PEDRO BRUGADA, MD,* MARIO TALAJIC, MD, ROBERT LEMERY, MD, FACC, PELAJO TORNER, MD, ROMAN LEZAUN, MD, THIERRY DUGERNIER, MD, HEIN J. J. WELLENS, MD, FACC

Maastricht, The Netherlands

To investigate how the electrophysiologic properties of the accessory pathway affect the occurrence of atrial fibrillation in the Wolff-Parkinson-White syndrome, programmed stimulation data of 57 patients with overt pre-excitation and 33 patients with a concealed accessory pathway with documented circus movement tachycardia were reviewed. Atrial fibrillation had occurred spontaneously in 31 (54%) of the 57 patients with the Wolff-Parkinson-White syndrome and in 1 (3%) of the 33 with a concealed accessory pathway ($p < 0.001$).

Sustained atrial fibrillation was induced in 23 of 31 patients with the Wolff-Parkinson-White syndrome and spontaneous atrial fibrillation (Group A), in 7 of 26 patients with the Wolff-Parkinson-White syndrome without spontaneous atrial fibrillation (Group B) and in 5 of 33 patients with a concealed accessory pathway (Group C). The anterograde effective refractory period of the accessory pathway was shorter in Group A than in Group B (252 versus 297 ms, $p < 0.001$). There were no differences among groups in PA interval, right to left atrium conduction time, cycle length of tachycardia and atrial and retrograde accessory pathway effective refractory period.

Atrial fibrillation is more frequent in patients with the Wolff-Parkinson-White syndrome than in those with a concealed accessory pathway. Patients with overt pre-excitation and atrial fibrillation have a shorter anterograde accessory pathway refractory period. It seems therefore that the anterograde rather than the retrograde conduction properties of the accessory pathway are the critical determinants of atrial fibrillation in the Wolff-Parkinson-White syndrome.

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Atrial fibrillation occurs in 10% to 30% (1–4) of patients with the Wolff-Parkinson-White syndrome, causing palpitation, syncope or even sudden cardiac death (5,6). Explanations for the occurrence of atrial fibrillation in patients with this syndrome include circus movement tachycardia degenerating into atrial fibrillation (1,7–9) and retrograde conduction of ventricular extrasystoles to the atrium causing the arrhythmia (1,9,10). Postoperative studies (3,11) in patients who have undergone surgical division of an accessory pathway have demonstrated a low incidence of spontaneous atrial fibrillation. This observation suggests that the accessory pathway plays an important role in the spontaneous occurrence of atrial fibrillation.

Patients with a concealed accessory pathway (12–15) could be expected to have an incidence of atrial fibrillation similar to that of patients with overt pre-excitation, although no study has specifically examined this hypothesis. The purpose of this study was to assess whether the electrophysiologic properties of the accessory pathway or atria, or both, play a role in the high incidence of atrial fibrillation in the Wolff-Parkinson-White syndrome. We compared clinical and electrophysiologic characteristics of patients with overt pre-excitation with those of patients with a concealed accessory pathway.

Methods

Study patients. The study group comprised 90 consecutive patients with an electrophysiologically proved accessory pathway who had 1) documented circus movement tachycardia or atrial fibrillation, or both; and 2) absence of associated structural heart disease. All patients had normal left atrial dimensions as assessed by M-mode echocardiogram.

Fifty-seven patients with anterograde and retrograde accessory pathway conduction and 33 patients with an accessory pathway with only retrograde conduction (concealed accessory pathway) were included. The mean age was 42 ± 17 years; 64% were men.

Electrophysiologic study. This was performed with patients in the fasting drug-free state according to a standard protocol (16). In brief, four quadripolar electrode catheters

From the Istituto di Cardiologia, Universita' degli Studi di Milano, Milan, Italy; Clinical Electrophysiology Laboratory, Academic Hospital, Maastricht, The Netherlands; and the *Cardiovascular Center, O.L.V. Hospital, Aalst, Belgium. Dr. Paolo Della Bella is recipient of a NATO–CNR fellowship grant.

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Address for reprints: Paolo Della Bella, MD, Istituto di Cardiologia, Universita' di Milano, Via Bonfadini 214, 20138 Milan, Italy.

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Table 1. Electrophysiologic Characteristics of Atrium, Accessory Pathway and Circus Movement Tachycardia in 90 Patients

	Group A (n = 31)	Group B (n = 26)	Group C (n = 33)	p Value
P–LRA	41 ± 7	43 ± 10	45 ± 9	NS
HRA–CS	73 ± 17	74 ± 13	74 ± 14	NS
Atrial ERP	216 ± 15	205 ± 24	214 ± 13	NS
APA ERP	252 ± 34	297 ± 67	—	<0.01
APR ERP	239 ± 47	249 ± 44	253 ± 43	NS
CL CMT	343 ± 62	333 ± 60	363 ± 71	NS

APA = accessory pathway anterograde; APR = accessory pathway retrograde; CL CMT = cycle length of circus movement tachycardia; ERP = effective refractory period; HRA–CS = high right atrium to coronary sinus conduction time; P–LRA = high to low right atrium conduction time. All values are in ms.

were introduced percutaneously through the femoral veins and were positioned in the high right atrium, the coronary sinus, across the tricuspid valve to record the His bundle electrogram and the apex of the right ventricle. Single and double ventricular extrastimuli were delivered at twice late diastolic threshold during sinus rhythm and ventricular pacing at rates of 100, 120 and 140 beats/min. Atrial stimulation included single extrastimuli during sinus rhythm and multiple pacing rates (100, 120 and 140 beats/min). Incremental atrial pacing was performed to a maximal rate of 250 beats/min.

The following variables were evaluated: 1) atrial conduction times (PA interval and high right atrium to coronary sinus interval); 2) rate of induced circus movement tachycardia; and 3) effective refractory period measurements of the atrium and accessory pathway at a pacing rate of 120 beats/min using the catheter closest to the site of insertion of the accessory pathway.

All patients gave informed consent to the study protocol, which was approved by the Ethical Committee of the institution.

Definitions. The following definitions were used. *Wolff-Parkinson-White syndrome:* Presence of the typical ECG pattern for this syndrome with a delta wave in association with episodes of paroxysmal tachycardia. Patients with intermittent pre-excitation or in whom pre-excitation became evident during atrial pacing were included in this group.

Concealed accessory pathway: An accessory pathway characterized by the presence of retrograde ventriculoatrial conduction without anterograde conduction. The absence of anterograde conduction was confirmed by the lack of pre-excitation during atrial pacing at the site of insertion of the accessory pathway.

Atrial vulnerability: The induction of sustained atrial fibrillation by a single atrial extrastimulus during sinus rhythm or atrial pacing.

Sustained atrial fibrillation: Atrial fibrillation of >5 min duration. The average ventricular rate during induced atrial fibrillation was measured over a 1 min period.

Statistical methods. Values are expressed as mean values ± SD. Continuous variables were compared between groups with use of the Student's *t* test or one-way analysis of variance when needed. Discontinuous variables were compared with use of the Fisher's exact test.

Results

Spontaneous Arrhythmia

Patient groups. The patients were classified into three groups on the basis of presenting arrhythmia and presence or absence of anterograde conduction of the accessory pathway. All 90 patients had a history of symptomatic tachycardia. Syncope occurred in five patients; two patients had been resuscitated from out-of-hospital cardiac arrest. All patients included in the study had electrocardiographically documented circus movement tachycardia. Among patients with the Wolff-Parkinson-White syndrome, 31 (54%) of 57 also had suffered from spontaneous atrial fibrillation (Group A). The remaining 26 patients had only circus movement tachycardia documented (Group B). Among patients with a concealed accessory pathway (Group C) only 1 (3%) of 33 had documented atrial fibrillation. The incidence of documented atrial fibrillation was much higher in patients with anterograde accessory pathway conduction than in patients with a concealed accessory pathway ($p < 0.001$).

Electrophysiologic Studies

All patients had orthodromic circus movement tachycardia induced at electrophysiologic study. There were no differences among the groups in cycle length of the induced tachycardia (Table 1).

Atrial conduction times and refractory periods (Table 1) were similar in all groups. The extent of shortening of the atrial effective refractory period when the pacing rate was increased was also similar in all groups.

Electrophysiologic characteristics of the accessory pathway (Table 1). The anterograde effective refractory period of the accessory pathway was shorter in Group A than in Group B patients. However, the retrograde refractory period of the accessory pathway did not differ significantly among groups. Finally, there were no differences in the location of the accessory pathway among groups. Three patients had mul-

Table 2. Incidence and Mode of Induction of Sustained Atrial Fibrillation (AF) in 55 Patients

	Group A	Group B	Group C
Induced sustained AF	23	7	5
Spontaneous from CMT	3	1	1
Atrial extrastimulus during sinus rhythm	5	1	0
Atrial pacing (<250 beats/min)	10	1	1
Atrial extrastimulus during atrial pacing	1	1	2
Atrial extrastimulus during CMT	2	1	1
Ventricular extrastimulus during ventricular pacing	2	1	0
Ventricular extrastimulus during CMT	0	2	0

AF = atrial fibrillation; CMT = circus movement tachycardia.

tiple accessory pathways and all had had spontaneous atrial fibrillation.

Incidence and Mode of Initiation of Atrial Fibrillation at Electrophysiologic Study (Table 2)

Atrial fibrillation was induced more frequently in patients with the Wolff-Parkinson-White syndrome (42 [73%] of 57) than in those with a concealed accessory pathway (13 [39%] of 33) ($p < 0.01$). Sustained atrial fibrillation was more frequent in patients with the Wolff-Parkinson-White syndrome and spontaneous documented atrial fibrillation (23 of 31) than in those without spontaneous atrial fibrillation (7 of 26) or those with a concealed accessory pathway (5 of 33). In this latter group, sustained atrial fibrillation was induced only in the patient who had had the arrhythmia spontaneously.

Spontaneous deterioration of circus movement tachycardia to atrial fibrillation occurred with the same incidence in all groups. However, the arrhythmia was sustained in only one patient with a concealed accessory pathway. Atrial fibrillation resulted from retrograde conduction of ventricular extrastimuli in five patients with the Wolff-Parkinson-White syndrome (two with and three without documented atrial fibrillation) and in none of the patients with a concealed accessory pathway.

Atrial vulnerability was documented in five Group A patients and one Group B patient but in none of the patients with a concealed accessory pathway. Atrial pacing at increasing rates (<250 beats/min) resulted in atrial fibrillation more frequently in patients with the Wolff-Parkinson-White syndrome and spontaneous atrial fibrillation than in patients in the other two groups. Atrial pacing and extrastimuli were required to induce atrial fibrillation in patients with a concealed accessory pathway.

Ventricular rate during induced atrial fibrillation (Table 3). The average and shortest RR intervals during atrial fibrillation induced at electrophysiologic study were significantly shorter in patients with the Wolff-Parkinson-White syndrome than in patients with a concealed accessory pathway, who had anterograde conduction only over the atrioventricular node. Furthermore, mean values of the shortest RR interval during atrial fibrillation were significantly shorter in patients with the Wolff-Parkinson-White syndrome with spontaneous atrial fibrillation (Group A) than in patients without spontaneous atrial fibrillation (Group B). Because of the small number of Group B patients having sustained atrial fibrillation at electrophysiologic study, no significant differences were found in the average RR interval between Group A and Group B.

Discussion

Although circus movement tachycardia is the most frequent presenting arrhythmia in patients with the Wolff-Parkinson-White syndrome, atrial fibrillation has been reported to occur. both in association with circus movement tachycardia and as the presenting arrhythmia, in 10% to 32% of these patients (1–3,10). Evidence from previous studies (3) indicates that the accessory pathway may play a major role in the development of atrial fibrillation. It is not clear, however, which electrophysiologic properties may predispose to the arrhythmia.

Mechanism of onset of atrial fibrillation. Spontaneous degeneration of circus movement tachycardia to atrial fibrillation occurred in a similar proportion of our patients with and without anterograde conduction over the accessory

Table 3. Mean and Shortest RR Intervals During Atrial Fibrillation Induced at Electrophysiologic Study in 90 Patients

	Group A (31 pts)	Group B (26 pts)	Group C* (33 pts)	p Value
Induced atrial fibrillation (no.)	25 (23)	17 (7)	13 (5)	
Mean RR (ms)	329 ± 41	340 ± 28	483 ± 66	<0.001†
Shortest RR (ms)	220 ± 37	255 ± 32‡	314 ± 34	<0.001†

*Anterograde conduction over the atrioventricular node; †Group C, versus A + B; ‡p = 0.003, Group B versus Group A. The numbers in parentheses indicate patients with sustained atrial fibrillation induced at electrophysiologic study. Pts = patients.

pathway. Retrograde conduction of ventricular ectopic beats or of ventricular paced beats can initiate atrial fibrillation both in patients with overt pre-excitation and in those with a concealed accessory pathway (9,13,17). This phenomenon was also observed in five of our patients during electrophysiologic study. However, atrial fibrillation was sustained in only one of our patients with a concealed accessory pathway.

Atrial vulnerability. Induction of sustained atrial fibrillation by atrial extrastimuli in patients with paroxysmal atrial fibrillation is considered a specific marker of atrial vulnerability (18–21). Other findings frequently associated with atrial fibrillation, such as disturbances of intraatrial conduction (22,23) or absent rate adaptation of the atrial refractory period (24), were not observed in our patients. Similar findings were reported in patients with the Wolff-Parkinson-White syndrome without heart disease (4,11). Recent data of Fujimura et al. (25), however, challenge the concept that atrial fibrillation in the Wolff-Parkinson-White syndrome is independent of atrial abnormalities; patients with inducible sustained atrial fibrillation had longer PA intervals than did control patients without atrial fibrillation.

Atrial fibrillation: role of the accessory pathway. On the other hand, in the same patient group (25), the anterograde accessory pathway refractory period was shorter in the group with atrial fibrillation than in the control group and there were no differences in retrograde properties. These findings stress the relation between anterograde conduction properties and atrial fibrillation.

Sharma et al. (5) reported a decrease in the incidence of atrial fibrillation in patients with the Wolff-Parkinson-White syndrome who underwent surgical division of the accessory pathway. Anterograde conduction was present in all of their 19 patients with documented atrial fibrillation and in 14 of 19 patients of a control group with only circus movement tachycardia. The remaining five patients of this latter group had a concealed accessory pathway and none of these five had documented atrial fibrillation. Similar findings were reported by Waspe et al. (11). These data suggest that not only the presence of the accessory pathway, but also the anterograde conduction properties may play a role in the spontaneous occurrence of atrial fibrillation. This hypothesis is consistent with our findings because surgical division of the accessory pathway also implies elimination of anterograde conduction.

Limitations of the study. Underestimation of the occurrence of atrial fibrillation in patients with a concealed accessory pathway may be a limitation of the study. Patients with atrial fibrillation and conduction only over the AV node may come less frequently to the physician's attention because they may be less symptomatic than patients with rapid anterograde conduction over an accessory pathway. The average ventricular rate during induced atrial fibrillation in patients with a concealed accessory pathway, however, was >120 beats/min during electrophysiologic study. On the other hand, because all patients had symptoms and documented tachycardia, the data reported are likely to represent a reliable estimate of the actual incidence of atrial fibrillation in the different groups of patients described in this study.

Conclusions. The present study demonstrates that the incidence of spontaneous atrial fibrillation is higher in patients with overt pre-excitation than in patients with a concealed accessory pathway. This finding suggests that the retrograde conduction properties of the accessory pathway are not the critical determinants of atrial fibrillation. The anterograde conduction properties of the accessory pathway distinguished patients with and without atrial fibrillation. A shorter anterograde accessory pathway refractory period allows faster ventricular rates during atrial fibrillation; in this setting the associated atrial stretch and hypoxia may contribute to sustaining the arrhythmia. Whether a peculiar arrangement of the atrial or ventricular insertion of the accessory pathway may affect both anterograde conduction and vulnerability to atrial fibrillation requires further investigation.

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